5.6 Geology/Soils

This section examines if Project implementation will expose people or structures to hazardous geologic or seismic conditions. The analysis focuses on geology and soils impacts associated with the adoption and implementation of the proposed General Plan, adoption and implementation of the revised Zone Code and Subdivision Code, and adoption and implementation of the Magnolia Avenue Specific Plan, as these actions have the potential to affect the placement of land uses on areas of known geologic or seismic hazards. The Citywide Design Guidelines and Sign Guidelines only address site planning, building design and community aesthetics and are thus not considered relevant to this analysis. **Appendix E** contains the Geologic and Seismic Technical Background Report performed by Wilson Geosciences, Inc. which includes detailed information regarding the City of Riverside's geologic conditions.

Environmental Setting

Landforms and Topography

The City of Riverside lies within the northern end of the Peninsular Ranges, approximately 12 miles south of the intersection with the Transverse Range. The Santa Ana Mountains are approximately 15 miles south and southwest of the City, while the San Jacinto Mountains are 10 miles east and northeast of the City of Riverside. The San Bernardino Mountains are about 20 miles north of the City.

A series of hills and small mountains surround the City of Riverside. These hills and mountains are between the two dominant San Jacinto and Santa Ana mountain ranges. They include La Loma Hills, Jurupa Mountains, Pedley Hills, Norco Hills and others. Within the City, surface elevations range from about 700 feet above mean sea level (amsl) near the Santa Ana River to over 1,400 feet amsl west of La Sierra. The highest point in the southern Sphere of Influence is Arlington Mountain, standing at 1,853 feet amsl approximately 1.5 miles northwest of Lake Mathews. Additionally, portions of Box Springs Mountain Reserve located in the northern Sphere of Influence area extend as high as 2,000 feet.

Mountains and hills typically have slopes of 15 to 50 percent; valley and basin areas usually have slopes of less than 15 percent. Within the City of Riverside, most natural slopes are very flat, generally less than 15 percent, with some slopes ranging from 15 to 25 percent in eastern and western portions of the City of Riverside. Many slopes in the Sphere of Influence are steeper than within the City. Areas around Lake Mathews are much steeper. Slopes along a substantial portion of the area west and south of Lake Mathews exceed 30 percent. A generalized map of the City of Riverside's geology is shown in **Figure 5-7**.

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Figure 5-7
Geologic Map (11x17 color)

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Figure 5-8
Faults and Fault Zones (11x17 color)

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Seismic Activity

No Fault-Rupture Hazard Zone, as designated by the California Department of Conservation (1997 and 1999), exists within the Planning Area. However, the City is located in a region with several active fault lines. **Figure 5-8** (Faults and Fault Zones) shows the most significant faults affecting the Planning Area, including the San Andreas, San Jacinto and Elsinore faults.

The San Andreas fault is at its closest point 11 miles from Downtown Riverside, abutting the San Bernardino Mountains. The San Andreas fault extends 600 miles from Eureka in Northern California's Humboldt County south to the Mexican border. The San Andreas fault is estimated to have the capability of producing up to an 8.3 magnitude (M) earthquake. The San Jacinto fault runs as close as seven miles from Downtown. This fault runs more than 125 miles, from northwest of El Centro in Imperial County to northwest of San Bernardino, passing through the intersection of Interstates 10 and 215, the City of Loma Linda and the Box Springs Mountains. This fault is estimated to have the capability of producing up to a 7.0M earthquake. The Elsinore fault passes within 13 miles of Downtown, extending approximately four miles west of Lake Mathews and Corona and south into the City of Lake Elsinore. This northwest-southwest trending fault is estimated to have the capability of producing up to a 6.0M earthquake.

Although no active or potentially active fault has been mapped at the surface within the City, one northwest-southeast trending unnamed fault is projected toward the southwest corner of the Planning Area south of Lake Mathews in the southern Sphere of Influence.[1] Additional faults are predicted to occur south of Lake Mathews; west of Lake Mathews near Mockingbird Canyon, and in the Box Springs Mountains. None of these projected faults are estimated to pose a ground rupture threat to the City of Riverside.

Geologic Hazards from Seismic Groundshaking

People and structures in the City of Riverside are subject to risks from the hazards associated with earthquakes. Seismic activity poses two types of hazards: primary and secondary. Primary hazards include ground rupture, ground shaking, ground displacement, and subsidence and uplift from earth movement. Primary hazards can induce secondary hazards such as ground failure (lurch cracking, lateral spreading and slope failure), liquefaction, water waves (tsunamis and seiches), movement on nearby faults (sympathetic fault movement), dam failure and fires. Potential seismic hazards affecting the City of Riverside include ground shaking, ground failure and liquefaction. The Planning Area is subject to moderate to high ground shaking from a seismic event occurring along regional faults.

The major geologic hazards associated with ground shaking include liquefaction and ground failure. Liquefaction occurs when ground shaking causes water-saturated soils to become fluid and lose strength. Liquefaction historically has been responsible for significant damage, creating problems with bridges, buildings, buried pipes and underground storage tanks.

[1]Geologic and Seismic Technical Background Report for Riverside, California, Wilson Geosciences, Inc., May 2004.

Liquefaction hazards are particularly significant along watercourses, a significant concern in the City given its proximity to the Santa Ana River and its numerous arroyos. **Figure 5-9** (Liquefaction Zones) illustrates the areas within the City with a high potential for liquefaction.

Within the Planning Area, the primary liquefaction areas are within the City limits including the area along the Santa Ana River, a broad area south and west of the Riverside Municipal Airport, a portion in western Riverside spanning La Sierra Avenue and a smaller area along the City's southern boundary. Most of the southern Sphere of Influence area is not susceptible to liquefaction, except for alluvial drainages leading into Lake Mathews.

Soils

The Planning Area contains the following general soil associations: Cajalco-Temescal-Las Posas, Traver-Domino-Willows, Cieneba-Rock Land-Fallbrook, Monserate-Arlington-Exeter and Hanford-Tujunga-Greenfield associations. Soil associations in the Planning Area are generally well-drained sandy loams that are moderately deep.

Soil Limitations

The degree and type of soil limitations that affect construction of roads and buildings are indicated in Table 5.6-1. A *slight* limitation indicates that soil properties generally are favorable for the specified use; any limitation is minor. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that one or more soil properties or site features are so unfavorable or difficult to overcome that a substantial construction effort, special design or intensive maintenance is required.

Soils containing high clay content often exhibit a relatively high potential to expand when saturated and to contract when dried out. This shrink/swell movement can adversely affect building foundations, often causing them to crack or shift, with resulting damage to the buildings they support. The shrink-swell potential for soils located in the City of Riverside is also indicated in Table 5.6-1. Soil permeability is the ability of a soil to transmit air or water. The rates given in Table 5.6-1 are for the soils as they occur in place.

Figure 5-9
Generalized Liquefaction Zones (11x17 color)

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Erosion

Most soils in the Planning Area are described as being well drained with slow runoff and moderately rapid permeability. However, the planning area slopes in the general northwest direction and portions consist of slopes greater than 30 percent. Soils within the City are susceptible to erosion and loss of topsoil. The likelihood of a soil to erode is also indicated in Table 5.6-1.

Table 5.6-1
Soil Limitations by Soil Type

Soil Types	Erosivity	Permeability	Shrink-Swell Potential	Depth (inches)	USDA Texture	Engineering Classification	
						AASHO	Unified
Altamont	Slight to moderate	Slow	High	0-23	Clay; cobbly in places.	A-7	CH, MH
Anza	Slight to moderate	Moderately rapid	Low	0-69	Fine sandy loam.	A-4	SM, ML
Arlington	Slight to moderate	Moderately slow	Low – moderate	0-24	Loam.	A-1	ML, CL
				24-36	Weakly cemented sandy loam.	A-2	SM
				36-60	Loamy coarse sand.	A-4, A-6	SP, SM
Bonsall	High	Very slow	Moderate	0-13	Loam.	A-4	ML
				13-30	Clay.	A-7	CL, CH
Buchenau	Moderate	Moderately slow over very slow	Moderate	0-52	Loam.	A-4, A-6	CL, ML
Buren	Slight to moderate	Moderately slow over very slow	Moderate	0-37	Clay loam.	A-6	CL
				37-52	Weakly cemented loam.	A-4	ML
Cajalco	High	Moderate	Moderate	0-13	Fine sandy loam.	A-2	SM
				13-22	Loam	A-6	SC
Chino	Slight	Moderately slow	Moderate	0-60	Silty clay loam.	A-6	CL
Cieneba	High	Rapid	Low	0-22	Gravelly coarse sandy loam.	A-1, A-2	SM, GM
Delhi	Water: Slight Wind: High	Rapid	Low	0-64	Fine sand and loamy fine sand.	A-2	SM
Dello	Slight	Moderately rapid to rapid	Low	0-62	Loamy fine sand, loamy sand and sand.	A-2	SM

Table 5.6-1
Soil Limitations by Soil Type

Soil Types	Erosivity	Permeability	Shrink-Swell Potential	Depth (inches)	USDA Texture	Engineering Classification	
						AASHO	Unified
Domino	Slight	Moderate over very slow	Moderate	0-27	Silt loam.	A-4	ML, CL
				27-36	Loam, weakly to strongly cemented with lime.	A-4	ML, CL
				36-63	Loam	A-4	ML, CL
Escondido	Moderate	Moderate	Low	0-34	Very fine sandy loam	A-4	ML
Exeter	Slight	Moderate	Moderate	0-16	Sandy loam and very fine sandy loam.	A-4	SM, ML
				16-37	Loam.	A-4	ML, CL
				37-50	Indurated hardpan.	…………	…………
				50-60	Coarse sandy loam.	A-2	SM
Fallbrook	Moderate	Moderate	Moderate	0-14	Sandy loam.	A-2	SM
				14-24	Sandy clay loam.	A-6	SC
				24	Weathered granite.		
Gorgonio	Slight to moderate	Rapid	Low	0-20	Loamy sand.	A-2	SM
				20-60	Gravelly loamy sand.	A-1	GM
				0-60	Gravelly or cobbly loamy sand.	A-1	GM
Grangeville	Slight	Rapid to moderate	Low	0-60	Loamy fine sand, fine sandy loam, sandy loam, coarse sand and fine sandy loam.	A-2, A-4	SM, SP, ML
Greenfield	Slight to moderate	Moderate	Low	0-43	Sandy loam	A-2	SM
				43-60	Loam.	A-4	ML, CL
Hanford	Slight to moderate	Moderately rapid to rapid	Low	0-40	Coarse sandy loam.	A-2	SM
				40-60	Loamy san and gravelly coarse sand.	A-1	SP, SM
				0-30	Cobbly coarse sandy loam.	A-2	SM
				30-6	Loamy coarse sand.	A-2	SM

Table 5.6-1
Soil Limitations by Soil Type

Soil Types	Erosivity	Permeability	Shrink-Swell Potential	Depth (inches)	USDA Texture	Engineering Classification	
						AASHO	Unified
Las Posas	Moderate	Moderate	High	0-12	Loam, clay loam.	A-6	CL
				12-32	Clay.	A-7	MH, CH
				32	Weathered gabbro.		
Madera	Slight	Very slow	High	0-19	Fine sandy loam.	A-4	SM
				19-26	Clay.	A-7	CH, MH
				26-37	Indurated hardpan.	…………	…………
				37-62	Loam.	A-6	CL
Metz	Slight	Rapid to very rapid	Low	0-48	Loamy fine and coarse sand that is gravelly in places.	A-2	SM, GM
				48	Sand that is gravelly in places.	A-2	SM
				0-30	Loamy fine sand.	A-2	SM
				30-60	Sandy loam.	A-2	SM
Monserate	Moderate	Moderately slow over very slow	Moderate	0-10	Sandy loam.	A-4	SM
				10-28	Sandy clay loam.	A-6	SC, CL
				28-45	Indurated hardpan.	…………	…………
Mottsville	Moderate	Rapid	Low	0-60	Loamy sand and loamy coarse sand.	A-2	SM
				0-24	Cobbly loamy sand or sandy loam.	A-2	SM
				24-60	Loamy sand.	A-2	SM
				0-20	Sandy loam.	A-2, A-4	SM
				20-60	Loamy coarse sand.	A-1, A-2	SM
Pachappa	Moderate	Moderate	Low – moderate	0-20	Fine sandy loam.	A-4	SM
				20-63	Loam.	A-4	ML

Table 5.6-1
Soil Limitations by Soil Type

Soil Types	Erosivity	Permeability	Shrink-Swell Potential	Depth (inches)	USDA Texture	Engineering Classification	
						AASHO	Unified
Placentia	Moderate	Very slow	High	0-18	Fine sandy loam and loam that is cobbly in places.	A-4	SM, ML
				18-39	Heavy clay loam.	A-6, A-7	CL, CM, MH
				39-57	Sandy clay loam.	A-6	CL
				57	Stratified alluvium.		
Porterville	Slight	Slow	High	0-66	Clay that is cobbly in places.	A-7	CH, MH
				0-36	Clay.	A-7	CH, MH
				36	Calcareous marl or sandstone.		
Ramona	Moderate	Moderately slow	Low	0-23	Sandy loam.	A-4	SM
				23-68	Sandy clay loam.	A-4, A-6	SC, ML, CL
				68-74	Fine sandy loam.	A-6	SC
				0-12	Sandy loam.	A-4	SM
				12-36	Clay loam.	A-4, A-6	SC, ML, CL
				36	Calcareous consolidated sediment.		
San Emigdio	Moderate	Moderate to moderately rapid	Low	0-60	Fine sandy loam.	A-4	SM
				0-40	Fine sandy loam.	A-4	SM
				40-60	Loamy sand.	A-2	SM
				0-60	Loam.	A-4, A-6	ML, CL
Temescal	High	Moderate	Moderate	0-17	Loam	A-4	ML, CL
				17	Fractured Latiteporphyry.		
Tujunga	Water: slight Wind: high	Rapid	Low	0-10	Loamy sand.	A-2	SM
				10-60	Sand.	A-1	SW, SP
				0-60	Gravelly loamy sand.	A-1	GM

Table 5.6-1
Soil Limitations by Soil Type

Soil Types	Erosivity	Permeability	Shrink-Swell Potential	Depth (inches)	USDA Texture	Engineering Classification	
						AASHO	Unified
Vista	Moderate	Moderately rapid	Low	0-24	Coarse sandy loam that is gravelly in places.	A-2	SM
				24	Weathered granodiorite.		

Source: U.S. Department of Agriculture, 1971.

Thresholds for Determining Level of Impact

For the purposes of this EIR, a significant impact will occur if implementation of the Project will:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: 1) rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist or based on other substantial evidence of a known fault; 2) strong seismic groundshaking; 3) seismic-related ground failure, including liquefaction; or 4) landslides;

- Result in substantial soil erosion or the loss of topsoil;

- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;

- Be located on expansive soil as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; or

- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Environmental Impact

Development pursuant to Project policies and regulatory standards will result in the addition of up to 38,100 new dwelling units and 39,600,000 square feet of new non-residential construction over the 20 year horizon of the General Plan within the Planning Area. Implementation of the Project will result in additional structures and people within the Planning Area that will be potentially exposed to geologic and/or soils/erosion hazards. This is considered a potentially significant impact.

During the construction phase of subsequent development projects, grading could temporarily expose soil surfaces to erosion through storm water runoff and wind. Long-term soil loss could also occur from the increased peak flows and additional runoff produced by paved or landscaped surfaces in the Planning Area. Uncontrolled flows could result in scouring or downcutting of stream channels where runoff velocities and volumes are high. This is considered a potentially significant impact

The General Plan Public Safety Element contains measures to minimize exposure to these hazards.

Policy PS-1.1: Ensure that all new development in the City abides by the most recently adopted City and State seismic and geotechnical requirements.

Policy PS-1.2: Locate important public facilities of City importance outside of geologically hazardous areas.

Policy PS-1-3: Provide the public with information on how to be prepared for a seismic event, and minimize any related damage or threat to health and public safety.

Policy PS-1-4: Use open space easements and other regulatory techniques to prohibit development and avoid creating public safety hazards where geologic instability is identified and cannot be mitigated.

Policy PS-1-5: Coordinate efforts between public safety, building officials, communication staff and others to create innovative public awareness programs.

The project includes a comprehensive update Riverside's Subdivision Code (Title 18 of the Riverside Municipal Code). Application and implementation of several sections of the Subdivision Code will reduce potential geologic impacts:

- Section 18.090.050 requires that geological/soils studies be prepared for land division proposals to identify and avoid/mitigate geologic and seismic hazards.
- Section 18.200.020 requires all development activity to comply with erosion control standards.
- Section 18.200.010 requires that grading plans be prepared for proposed subdivisions of land.
- Section 18.200.020 sets forth erosion control standards to which all development activity must comply. Also, all development activity is required to comply with erosion control standards in Section 18.200.020. Compliance with these regulations will avoid impact.

The General Plan policies and features of the Subdivision Code listed above will substantially lessen impacts relative to geologic hazards. In addition, the following ongoing

City standards and practices will also lessen potential geologic impacts. These standards and practices will continue to be in effect, regardless of the status of Project adoption.

- Require geologic and/or geotechnical studies for proposed new development projects located in areas identified as susceptible to landslides and liquefaction pursuant to state law. Require that feasible recommendations be incorporated into the design of future projects. In addition, where appropriate, require applicants to incorporate measures to stabilize and maintain slopes on a site-by-site basis.

- Implement applicable portions of the City's Grading Code (Title 17) to ensure that grading associated with new development projects is conducted in accordance with appropriate geotechnical engineering standards.

- Ensure that all development conforms to the Uniform Building Code.

However, the degree to which the above project features will reduce potential geologic impacts cannot be precisely quantified. As such, the project's potential impacts are still considered significant and mitigation is required.

Mitigation Measures

The following mitigation measures are needed to reduce the significance of potential geologic impacts.

GS-1 Geologic and/or geotechnical studies shall be required for proposed new development projects located in areas identified as susceptible to erosion; binding mitigation strategies must be adopted. These areas are generally identified on **Figures 5-7** and **5-9** and include areas with high soil limitations as indicated in Table 5.6-1. In addition, the City may require individual development applicants to incorporate measures to stabilize and maintain slopes on a site-by-site basis.

GS-2 Continually update development standards and adopt the latest building construction codes to guide future development in areas with known geologic and seismic-related hazards.

Level of Impact after Mitigation

With adherence to and implementation of the above General Plan policies and mitigation measures, the Project's potential geologic impacts will be reduced below a level of significance at the programmatic level.

The significance of geologic impacts resulting from specific future development projects will be evaluated on a project-by-project basis. If project-level impacts are identified, specific mitigation measures will be required per CEQA.

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